IMPROVED PROCESS FOR DEPOSITION OF SEMICONDUCTOR FILMS

Abstract of the Disclosure

Chemical vapor deposition processes utilize chemical precursors that allow for the deposition of thin films to be conducted at or near the mass transport limited regime. The processes have high deposition rates yet produce more uniform films, both compositionally and in thickness, than films prepared using conventional chemical precursors. In preferred embodiments, trisilane is employed to deposit thin films containing silicon are useful in the semiconductor industry in various applications such as transistor gate electrodes.

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Drawings

7

Level - 2
Version 1.1
Updated - 8/01/01

FIGURE 1

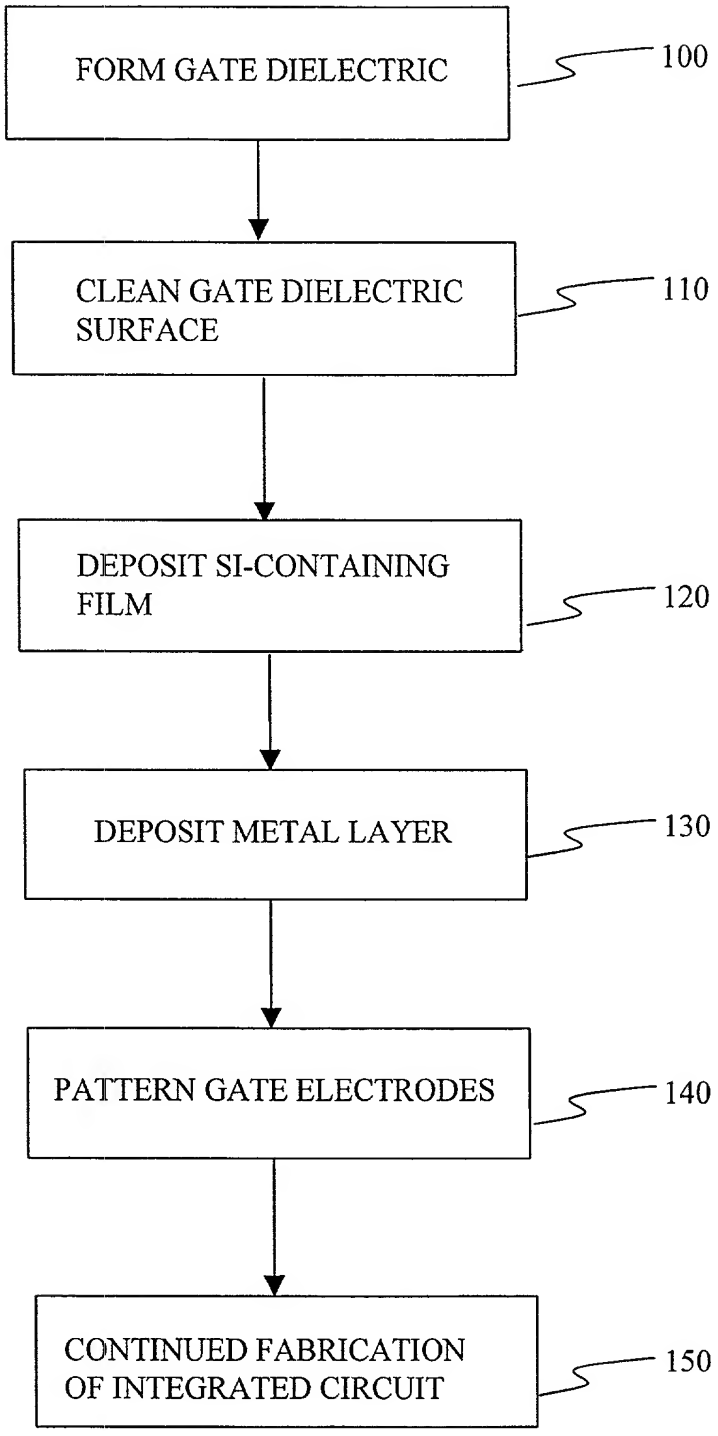

FORM GATE DIELECTRIC
100
CLEAN GATE DIELECTRIC SURFACE
110
DEPOSIT SI-CONTAINING FILM
120
DEPOSIT METAL LAYER
130
PATTERN GATE ELECTRODES
140
CONTINUED FABRICATION OF INTEGRATED CIRCUIT
150

FIGURE 2

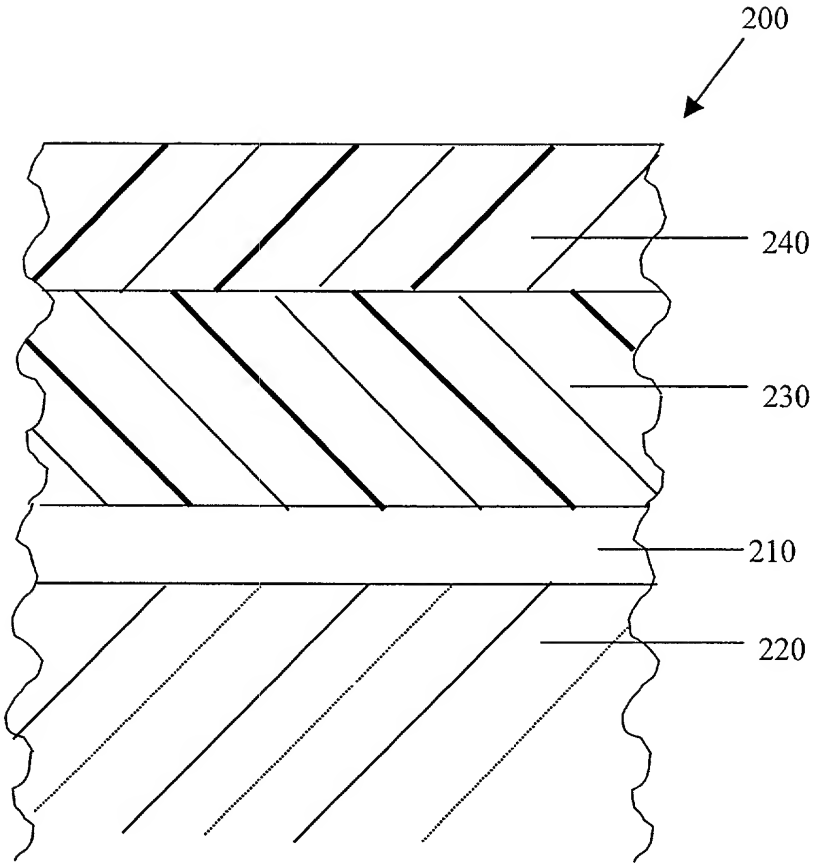


FIGURE 3

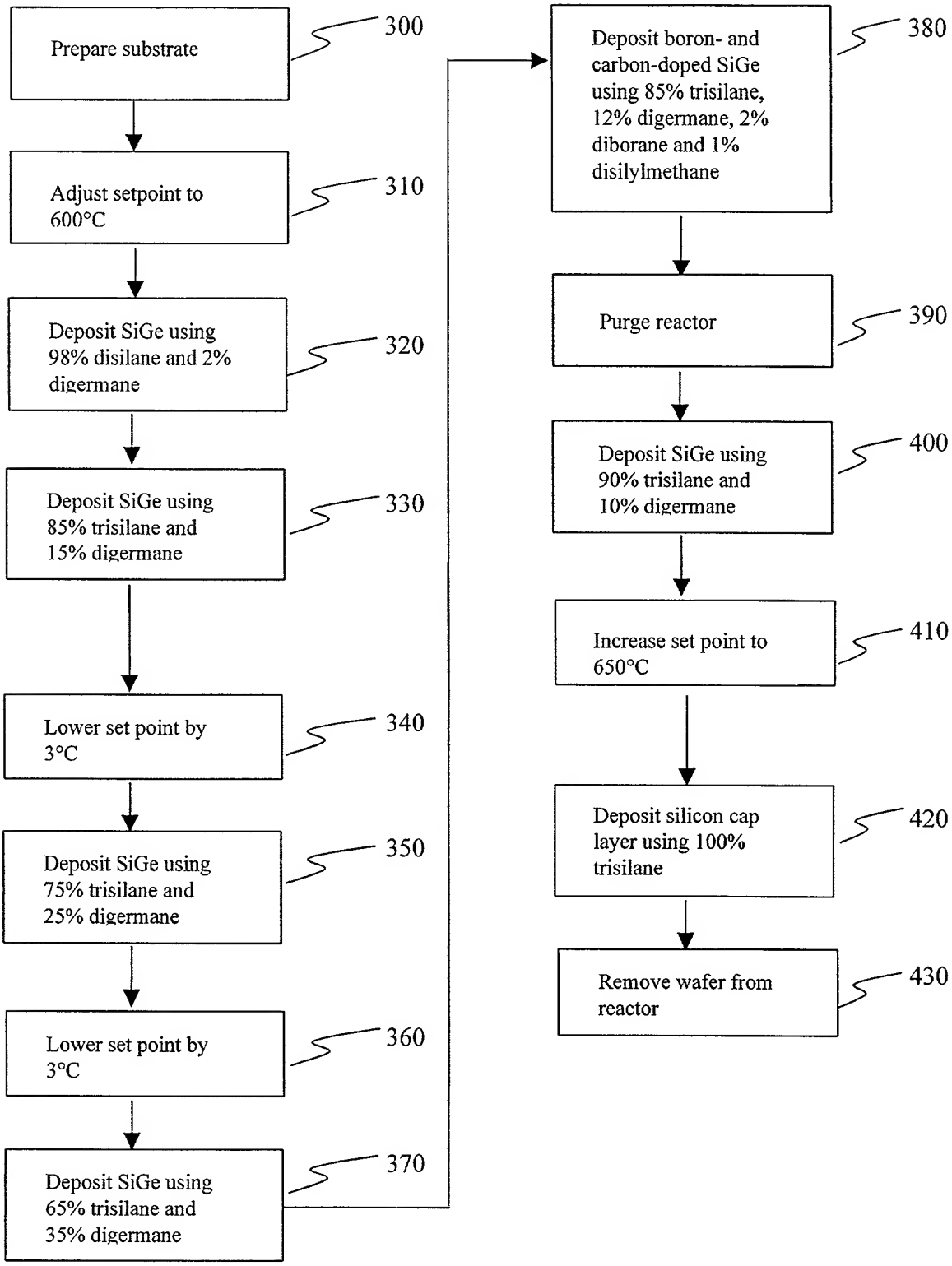

Prepare substrate
300
Adjust setpoint to 600°C
310
Deposit SiGe using 98% disilane and 2% digermane
320
Deposit SiGe using 85% trisilane and 15% digermane
330
Lower set point by 3°C
340
Deposit SiGe using 75% trisilane and 25% digermane
350
Lower set point by 3°C
360
Deposit SiGe using 65% trisilane and 35% digermane
370
Deposit boron- and carbon-doped SiGe using 85% trisilane, 12% digermane, 2% diborane and 1% disilylmethane
380
Purge reactor
390
Deposit SiGe using 90% trisilane and 10% digermane
400
Increase set point to 650°C
410
Deposit silicon cap layer using 100% trisilane
420
Remove wafer from reactor
430

FIGURE 4

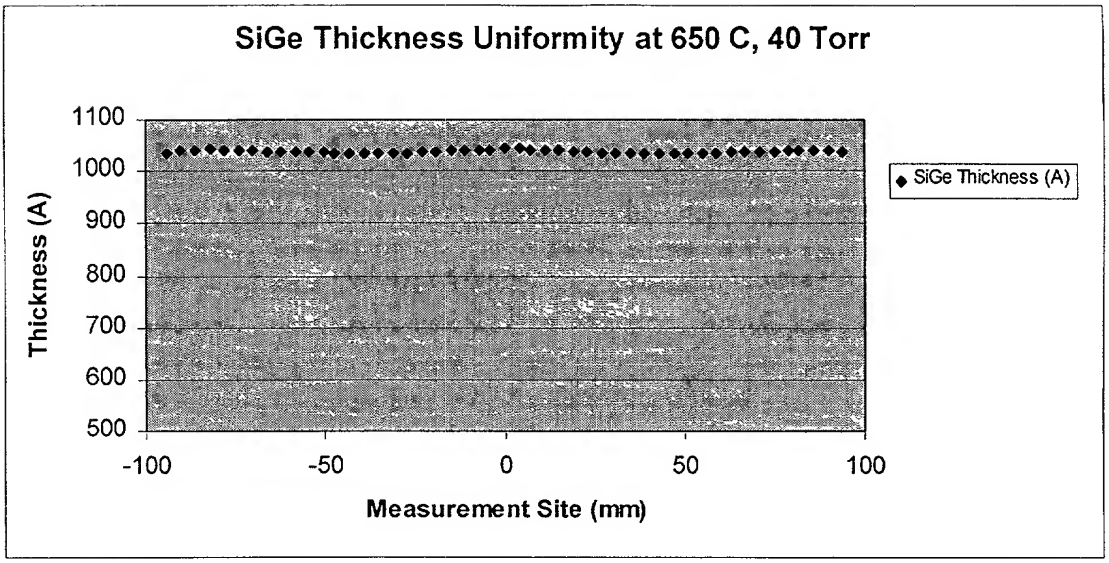

SiGe Thickness Uniformity at 650 C, 40 Torr
Thickness (A)
1100
1000
900
800
700
600
500
-100
-50
0
50
100
Measurement Site (mm)
SiGe Thickness (A)

FIGURE 5
SEM Photomicrograph of Si-Ge Film Deposited Using Silane and Germane

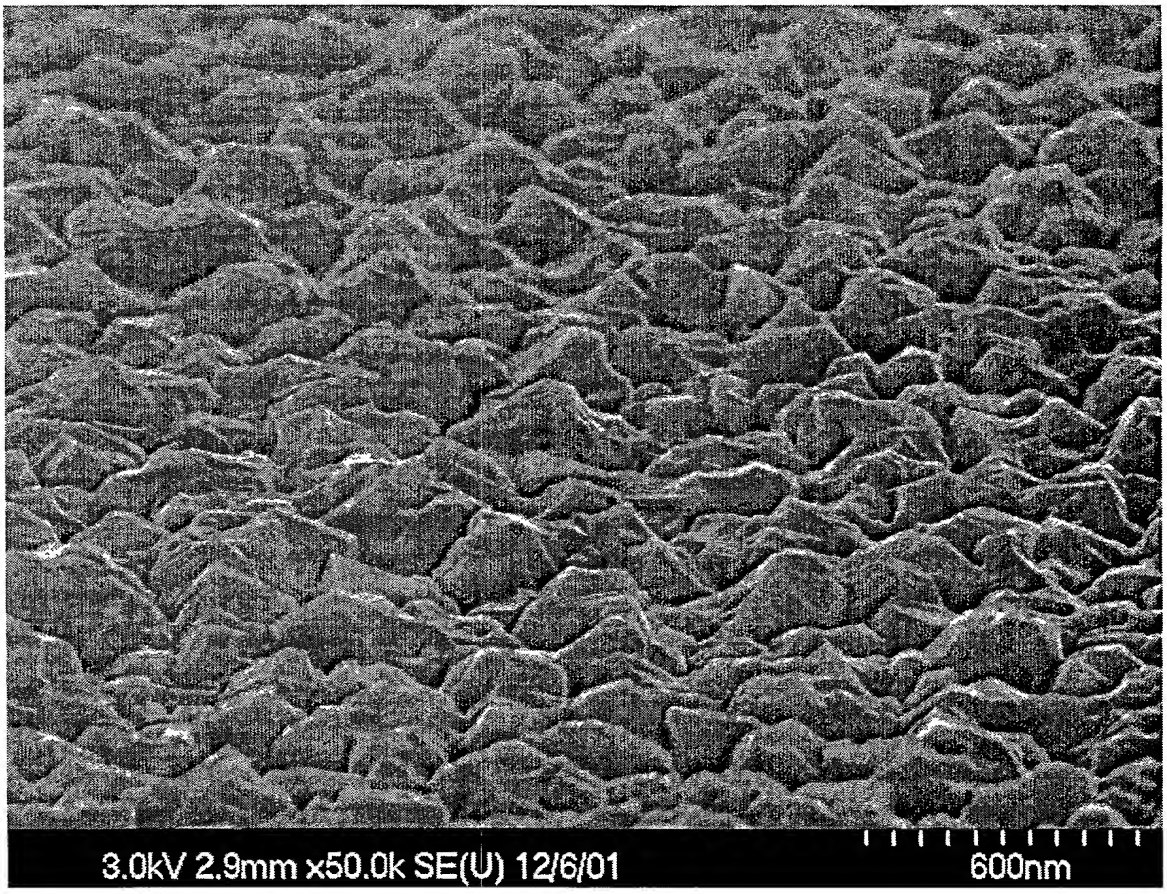


FIGURE 6
SEM Photomicrograph of Si-Ge Film Deposited Using Silane and Germane

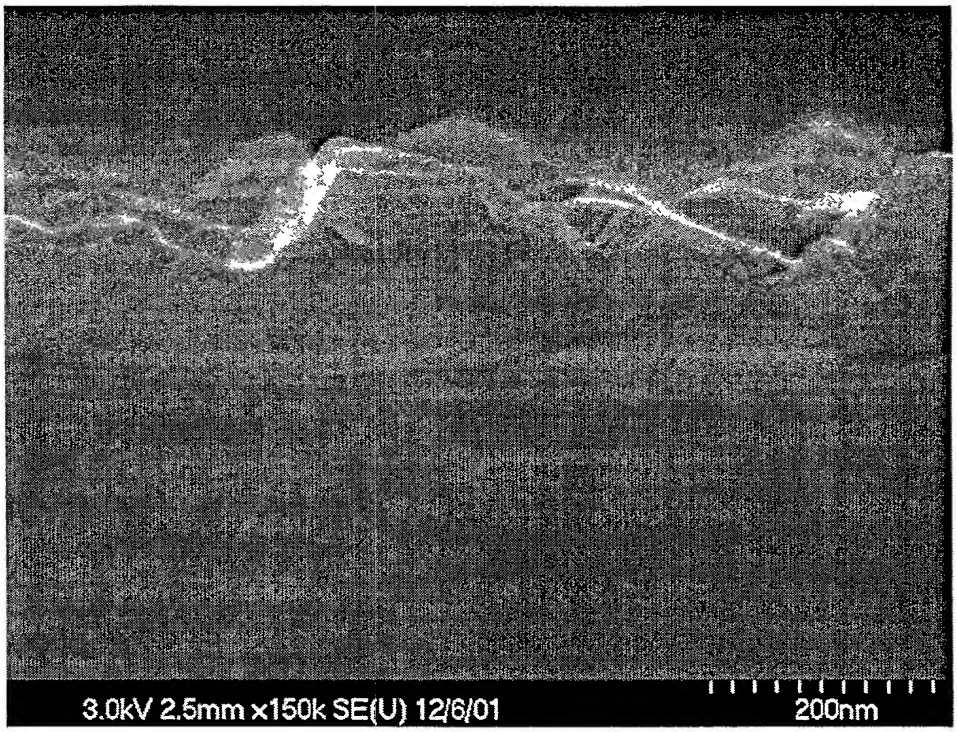


FIGURE 7
SEM Photomicrograph of Si-Ge Film Deposited Using Trisilane and Germane

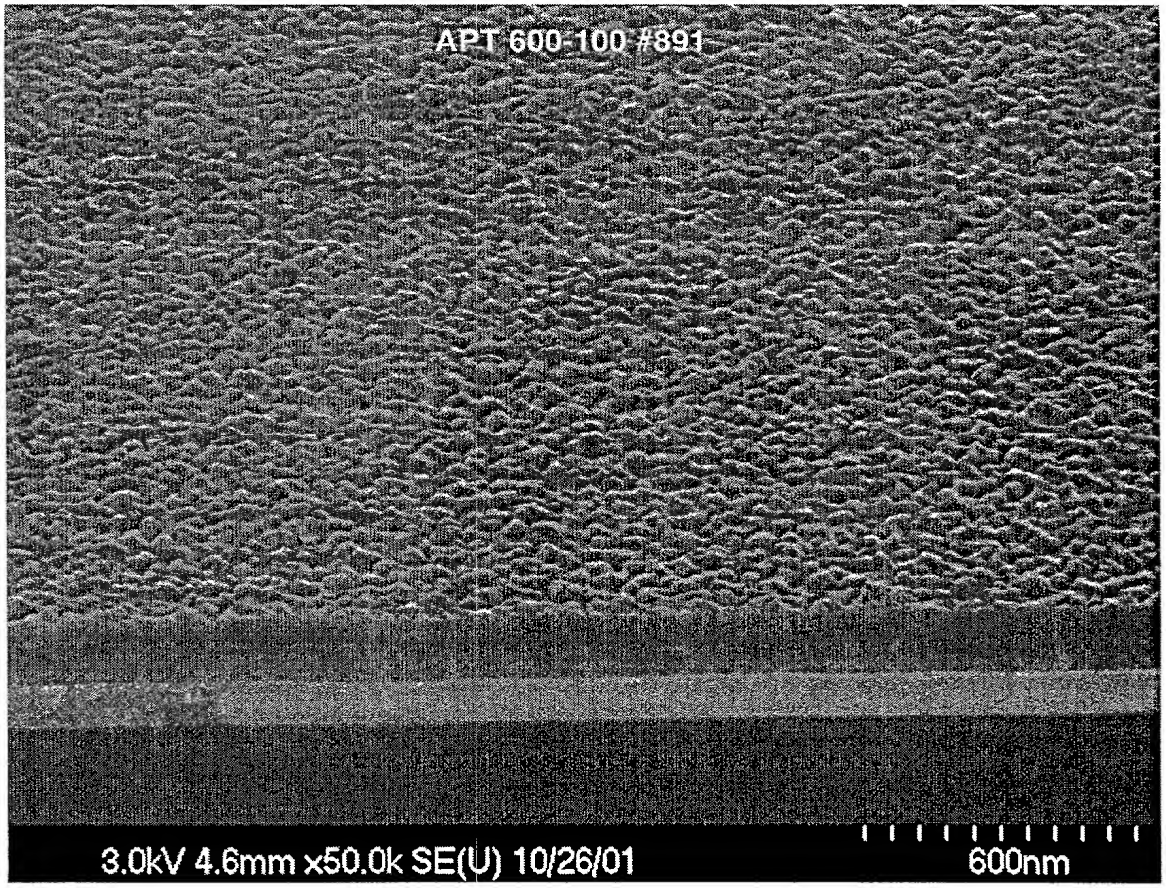


FIGURE 8
SEM Photomicrograph of Si-Ge Film Deposited Using Trisilane and Germane

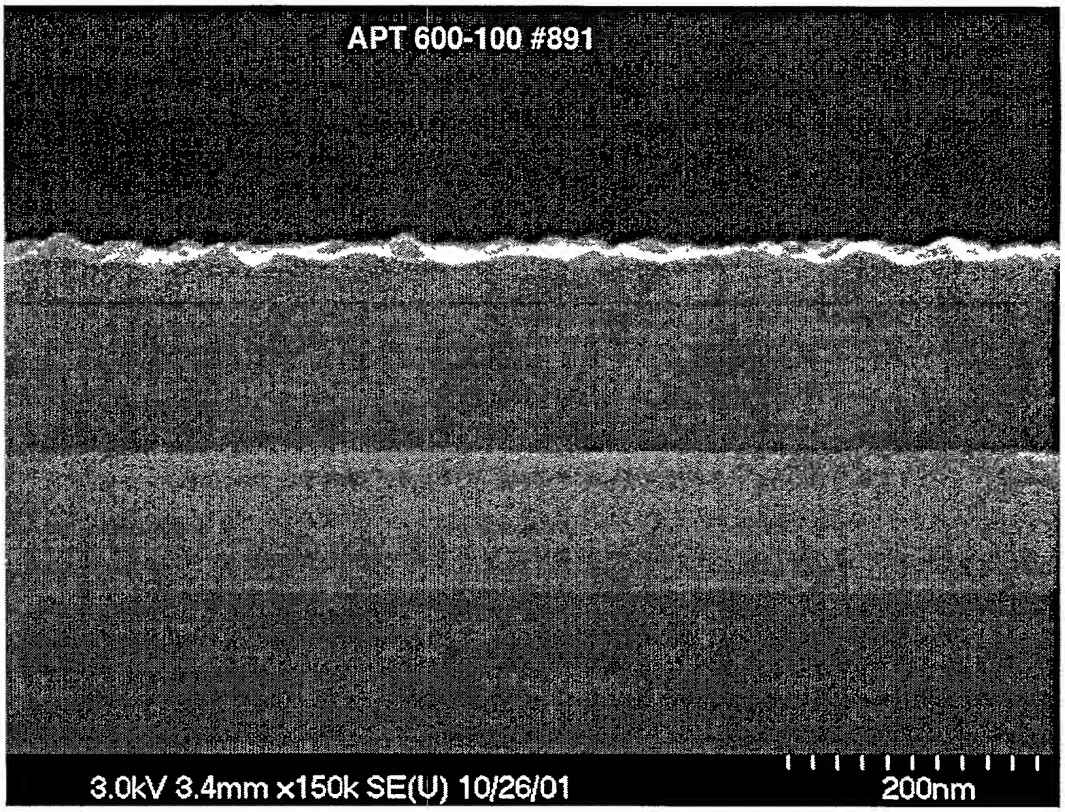


FIGURE 9
TEM Photomicrograph of Si-N Film Deposited Using Trisilane and Atomic Nitrogen

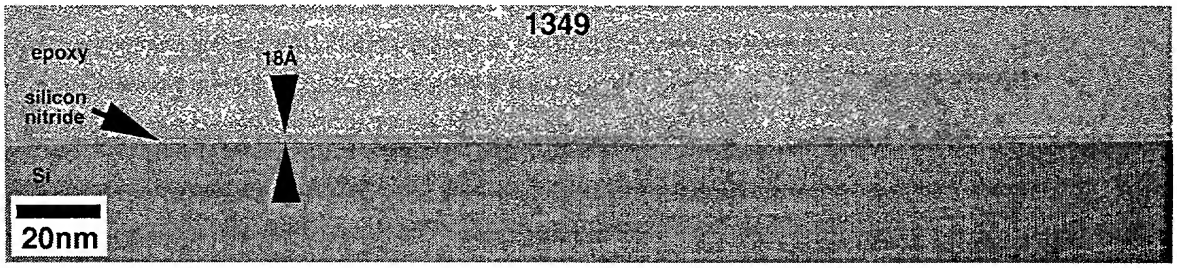


FIGURE 10

ARRHENIUS PLOT FOR SILANE, DISILANE AND TRISILANE

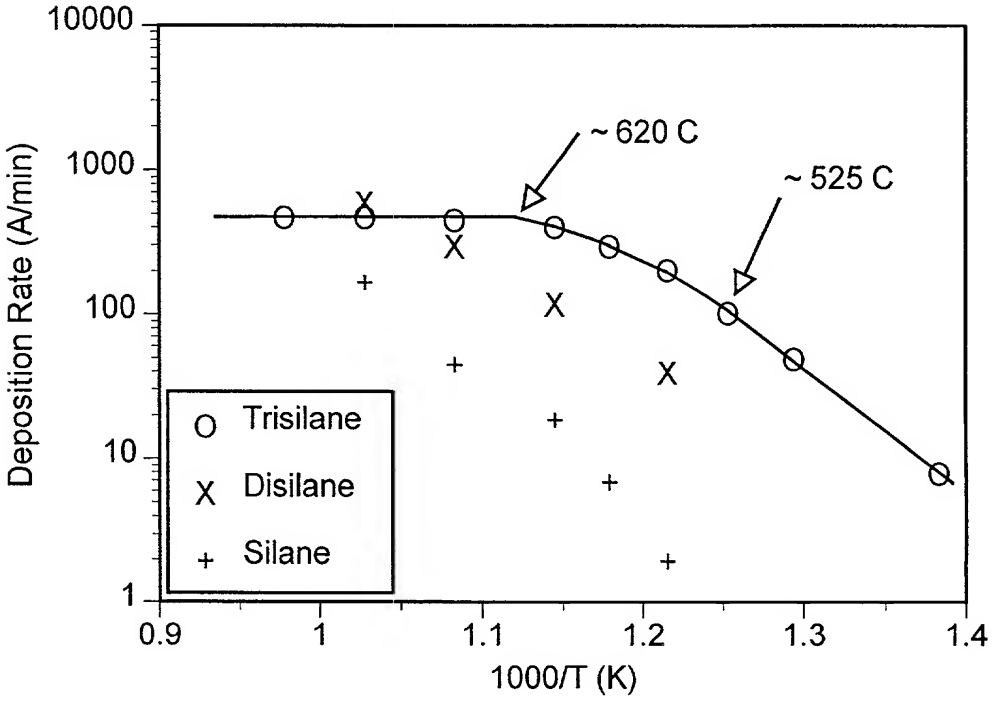


FIGURE 11

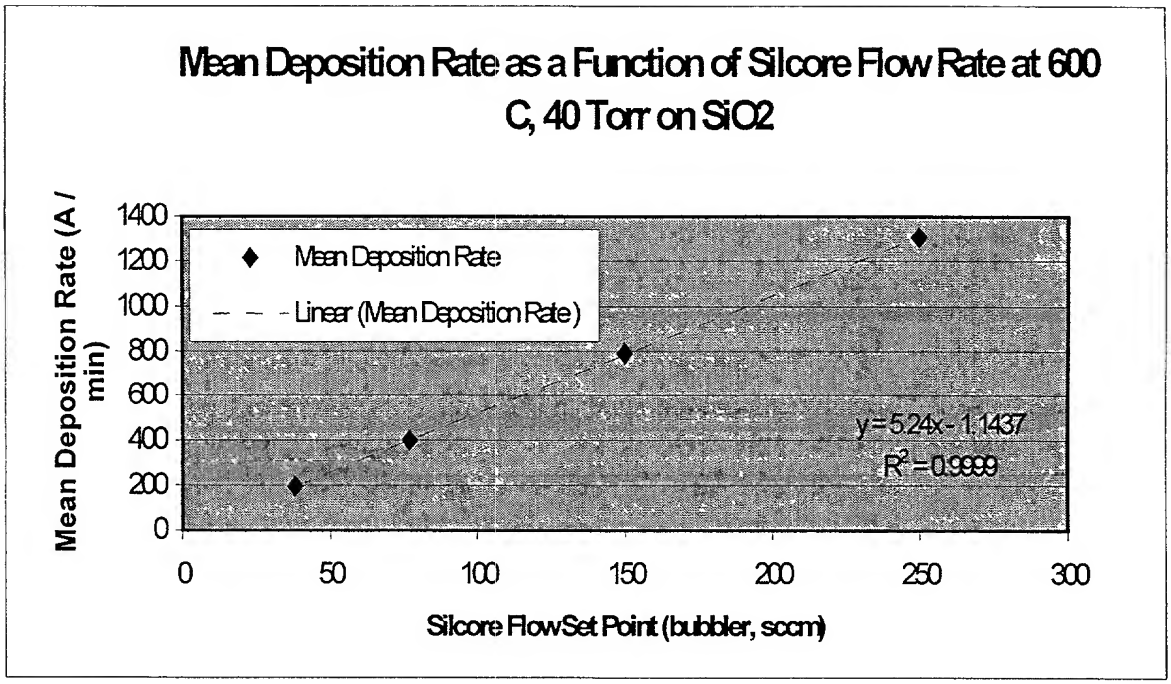

Mean Deposition Rate as a Function of Silcore Flow Rate at 600 C, 40 Torr on SiO2
Mean Deposition Rate (A / min)
1400
1200
1000
800
600
400
200
0
Mean Deposition Rate
Linear (Mean Deposition Rate)
y = 5.24x - 1.1437
R² = 0.9999
0
50
100
150
200
250
300
Silcore FlowSet Point (bubbler, sccm)

FIGURE 12

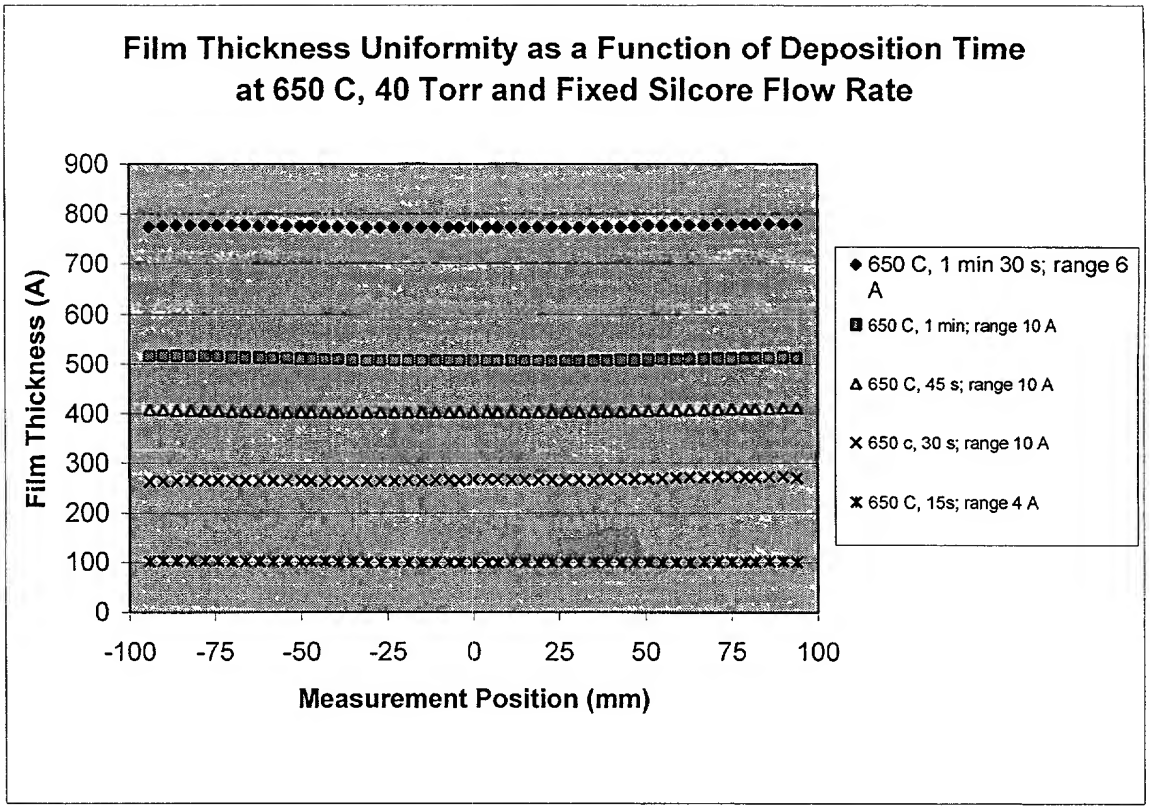

Film Thickness Uniformity as a Function of Deposition Time at 650 C, 40 Torr and Fixed Silcore Flow Rate
Film Thickness (A)
900
800
700
600
500
400
300
200
100
0
-100
-75
-50
-25
0
25
50
75
100
Measurement Position (mm)
650 C, 1 min 30 s; range 6 A
650 C, 1 min; range 10 A
650 C, 45 s; range 10 A
650 c, 30 s; range 10 A
650 C, 15s; range 4 A

FIGURE 13

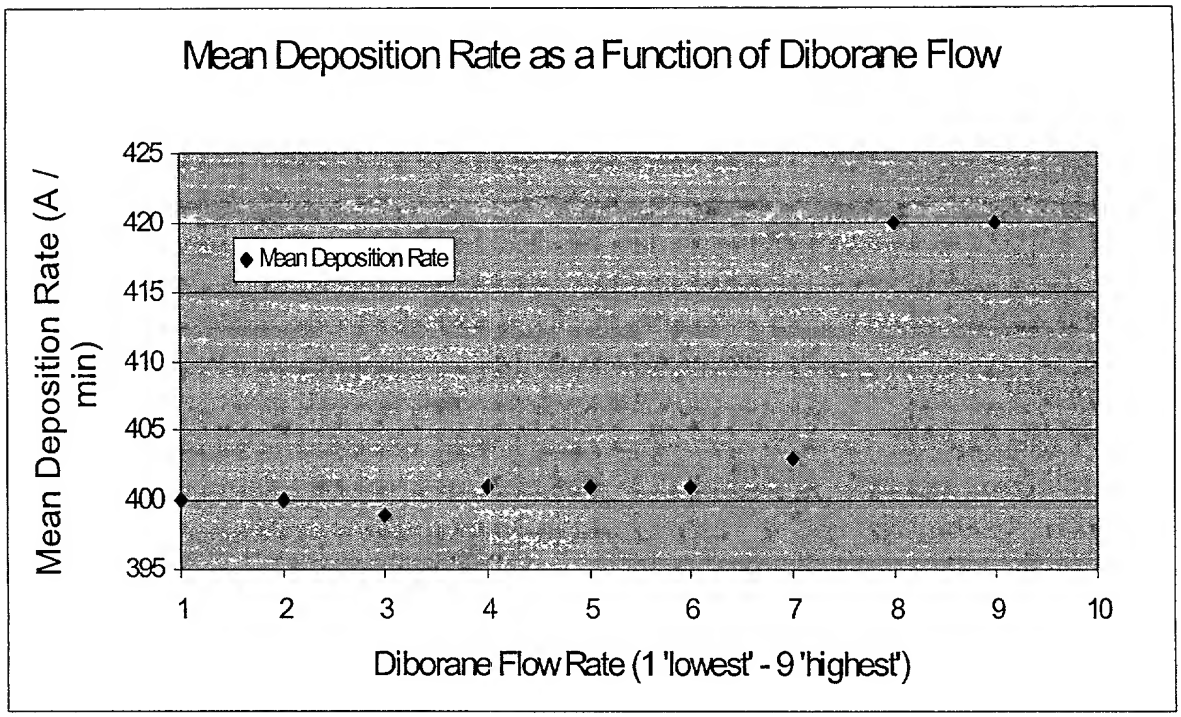

Mean Deposition Rate as a Function of Diborane Flow
Mean Deposition Rate (A / min)
425
420
415
410
405
400
395
Mean Deposition Rate
1
2
3
4
5
6
7
8
9
10
Diborane Flow Rate (1 'lowest' - 9 'highest')

FIGURE 14

RBS ERD SPECTRUM OF AMORPHOUS SILICON FILM DEPOSITED USING TRISILANE AT 600°C, 40 TORR

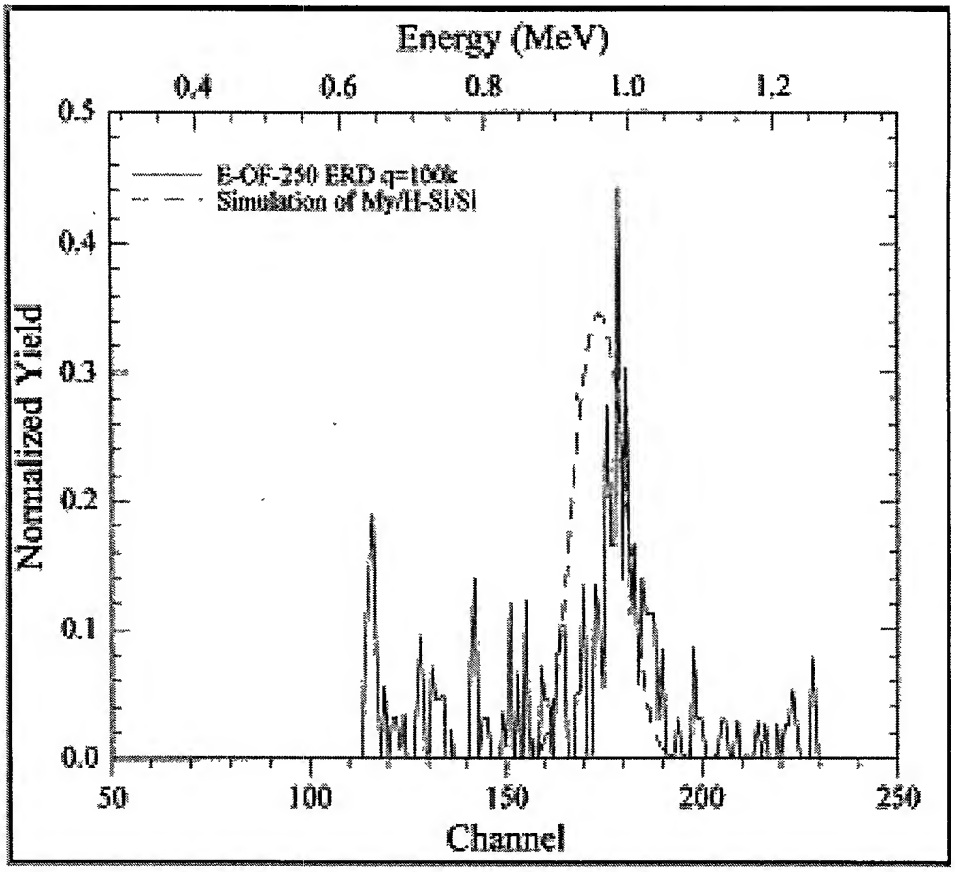


FIGURE 15

X-RAY DIFFRACTION SPECTRA FOR FILMS DEPOSITED USING TRISILANE AT 600°C, 650°C, 700°C AND 750°C (BOTTOM TO TOP, RESPECTIVELY)

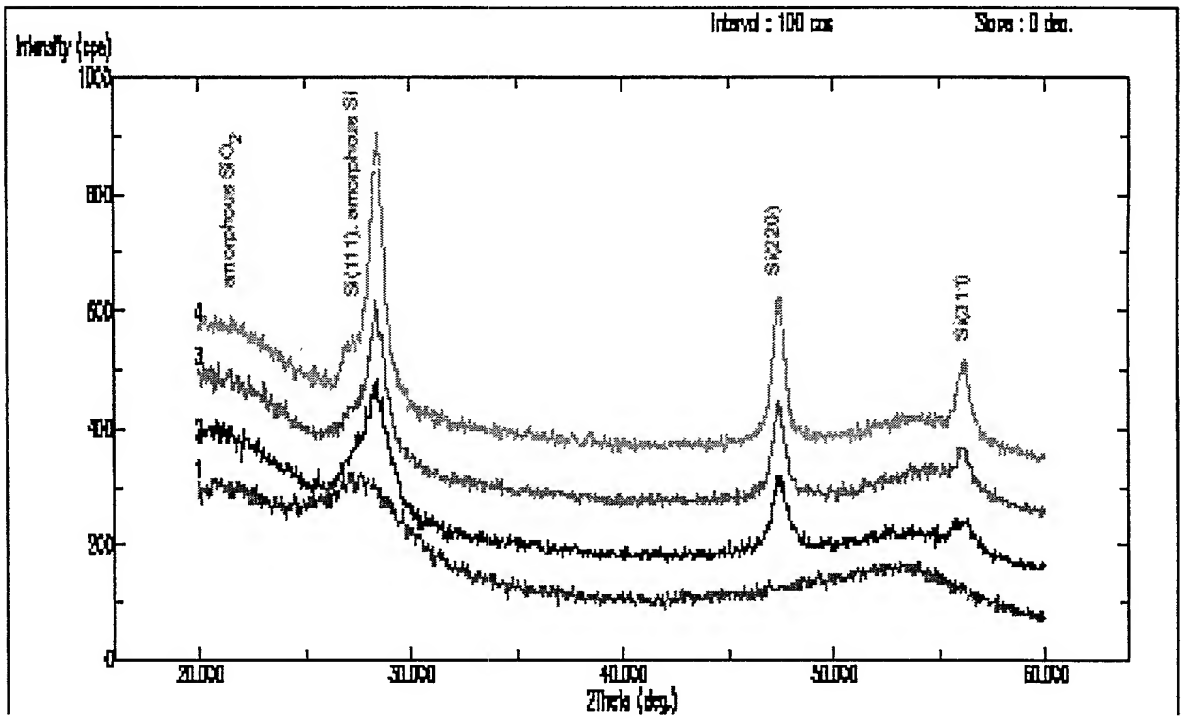


FIGURE 16

CROSS SECTION OF POLYCRYSTALLINE SILICON FILM

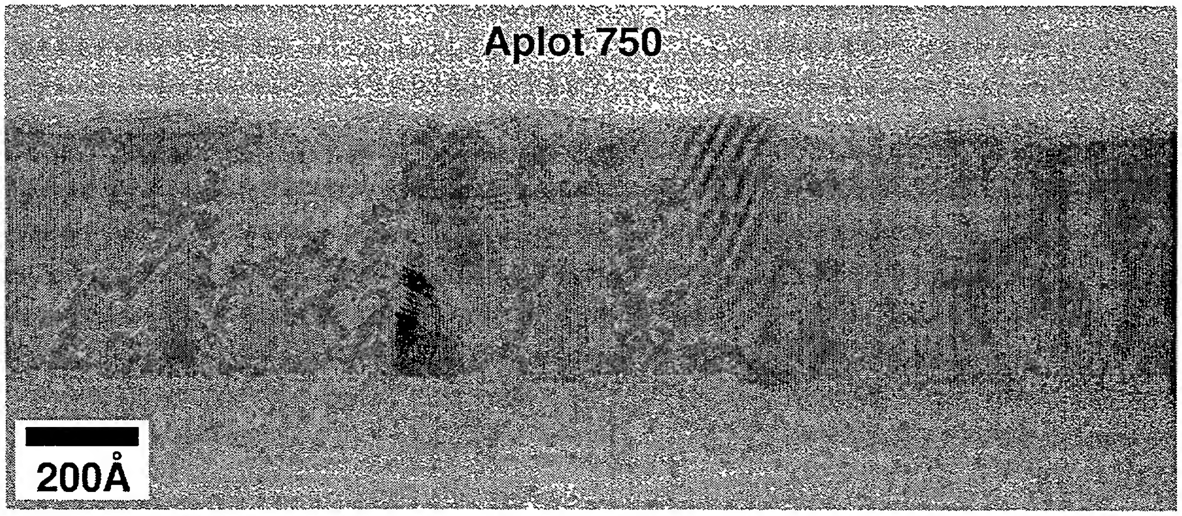


FIGURE 17

SAD PATTERN OF POLYCRYSTALLINE SILICON FILM

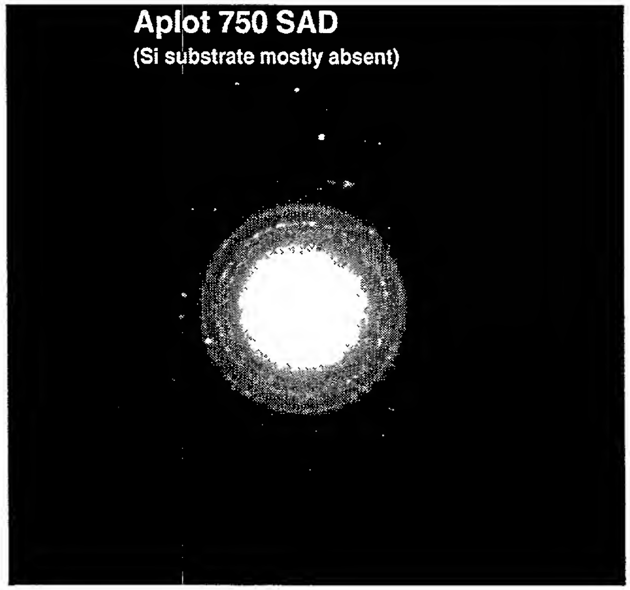


FIGURE 18

CROSS SECTION OF CONFORMAL AMORPHOUS SILICON FILM

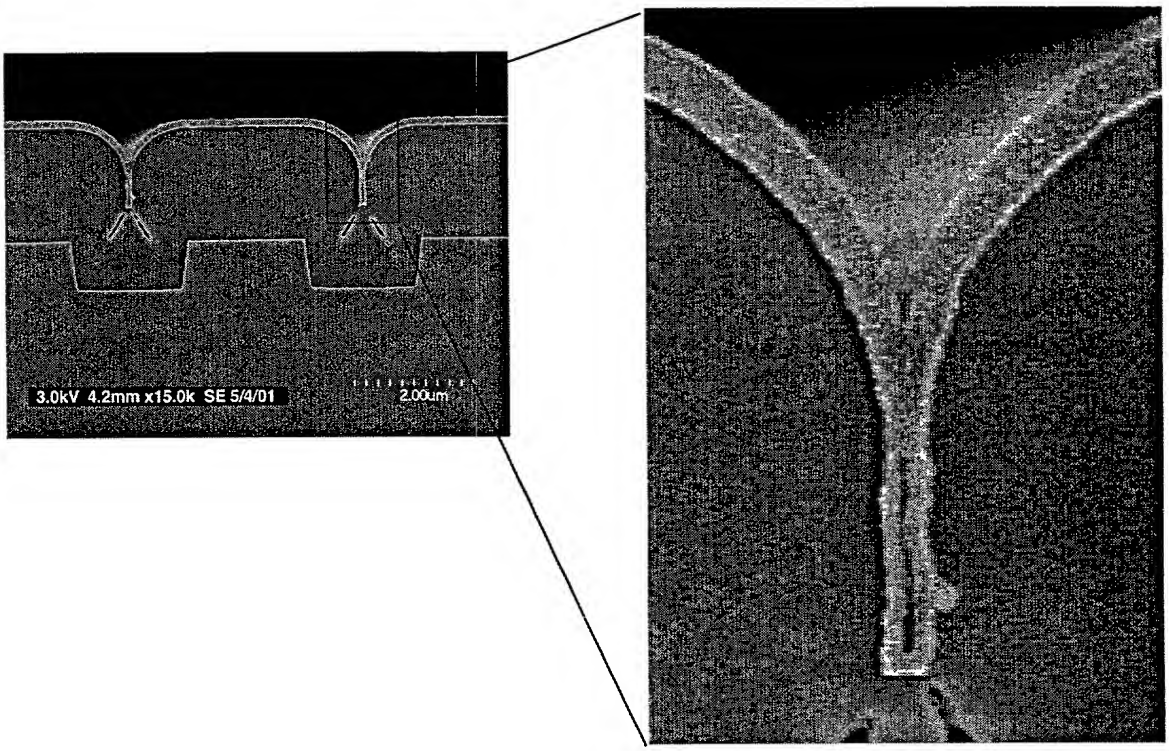


FIGURE 19

RBS SPECTRUM OF SILICON NITRIDE FILM

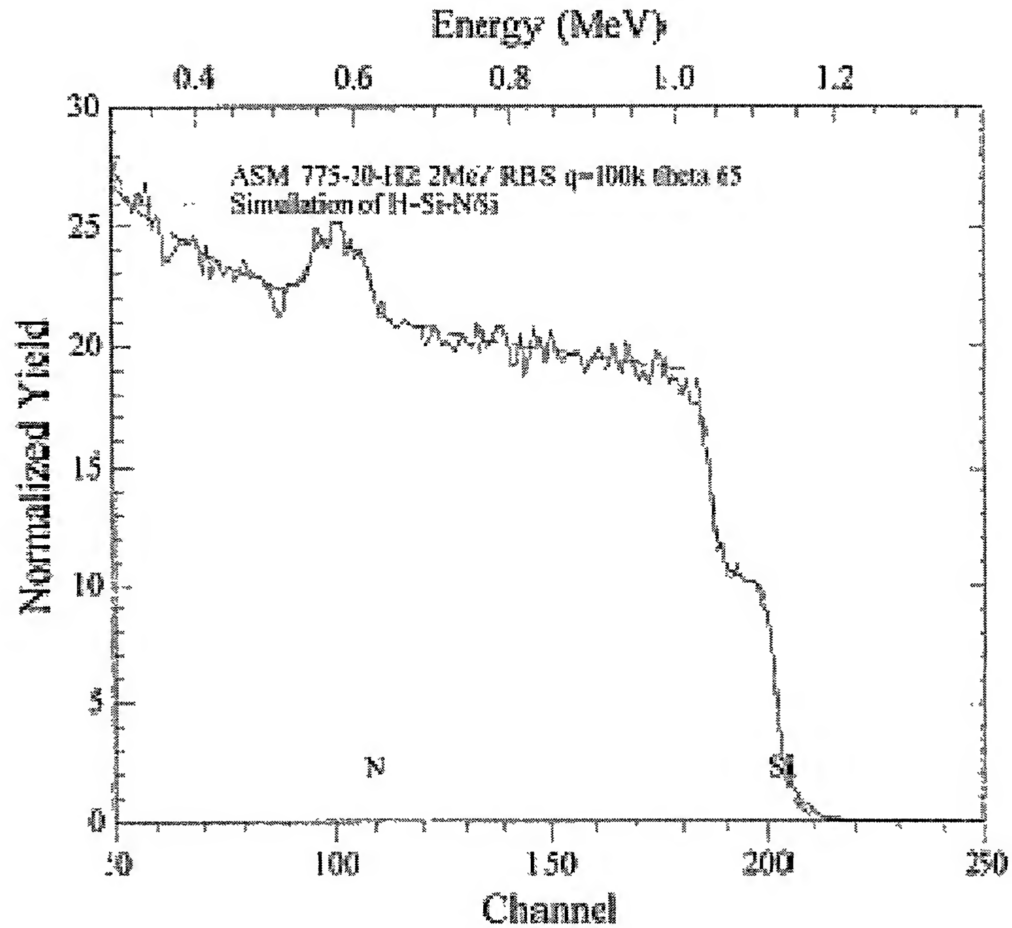
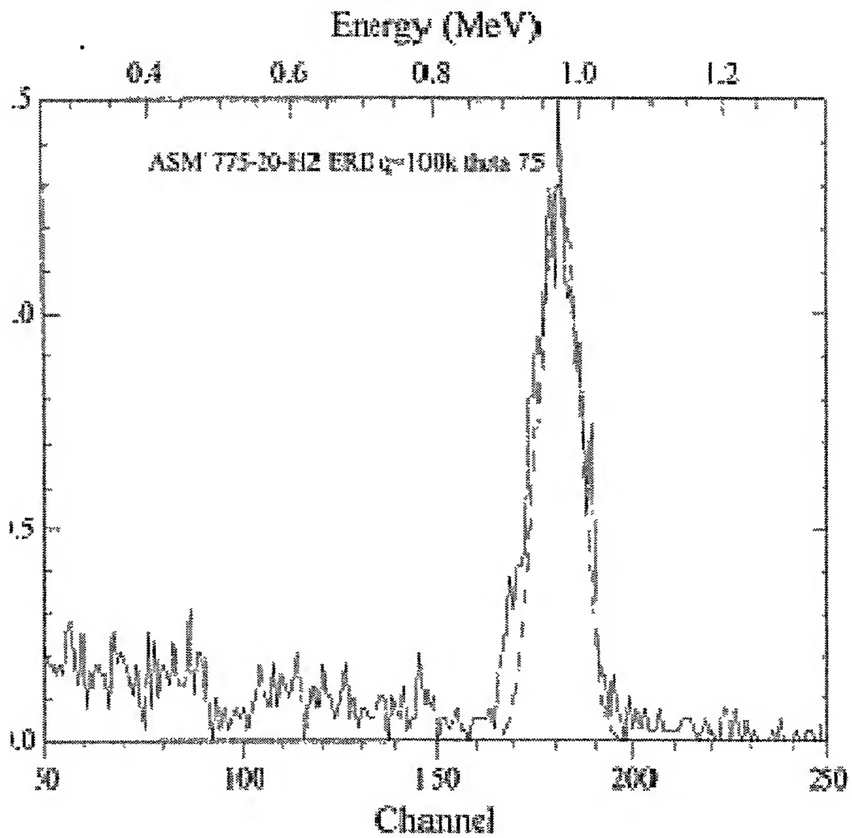


FIGURE 20

RBS ERD SPECTRUM OF SILICON NITRIDE FILM



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Miscellaneous

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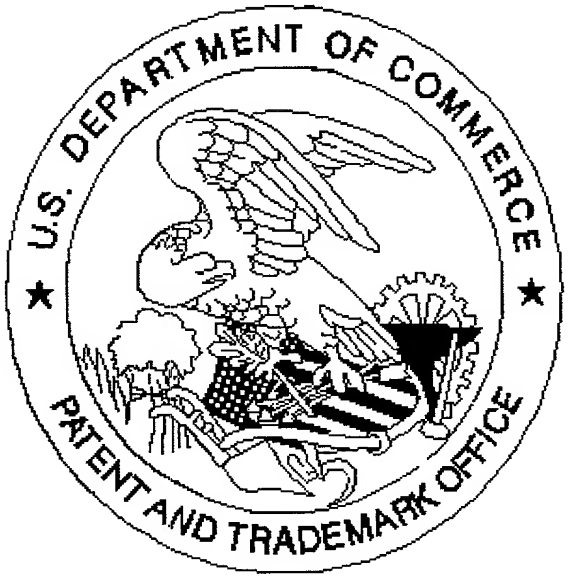

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